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Metacognitive Awareness of STEAM Education among Primary Stage Teachers in Jordan

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ABSTRACT
This study aimed to investigate the level of metacognitive awareness of STEAM education among primary stage teachers in Jordan. It also aimed to identify the impact of school type, experience, and specialization on the level of Metacognitive awareness. Via purposive sampling, 370 science, computer science, social science and humanities, and mathematics teachers were selected, who already know about the STEAM approach, from public and private schools in Amman and Madaba Governorates. The researcher developed a five-point Likert-type scale to measure metacognitive awareness among primary school teachers about the STEAM approach. The researcher verified the content validity by presenting the instrument to a group of experts in curricula and teaching methods to determine the extent of the clarity and comprehensiveness of the items. The researcher applied the questionnaire to a pilot of 30 from outside the sample to calculate the constructive validity and reliability. The results of the application showed constructive validity ranging between (.65 and .82). The researcher concluded that the level of metacognitive awareness among teachers with 3 years and more experience who work in the private sector is higher than those who work in the public sector. The results also showed no significant difference in the level attributed to the specialization variable. The researcher recommends that the Ministry of Education should prepare a successful education reform process in addition to adopting a unified reform plan with clear educational goals and outcomes.

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Introduction

Teachers have been following the same procedures inside classrooms for many decades during which they send information and students receive it. Teachers are the center of the teaching-learning process. Students retrieve information to answer questions of the exams (Sarıoğlu, 2021;

Sarıoğlu & Girgin, 2020). The relationship between standards and objectives has long been tried to be improved to further student achievement (Ambusaidi et al., 2018; Kurz et al., 2010; Webb, 2007) along with other areas of education such as skills (Çepni & Sarıoğlu, 2021; OECD, 2019), or STEM competencies (Bahşi & Açıkgül Fırat, 2020; Gill, 2019; Petrov & Atanasova, 2020; Uysal & Cebesoy, 2020).

Educational experts around the world have been reconsidering the construction of educational systems (Beach et al., 2014). They think that curriculum integration is emergent so that teachers and students cope with the skills of the 21st century (Cavas et al., 2021; Çınar et al., 2022; Karademir & Yıldırım, 2021). Learning-teaching systems must be transformed to fulfill this integration (Sedova et al., 2016). The goals are beyond achieving high scores in Math and Science. It is the idea of a generation able to self-regulate, learn, and merge in societies professionally. Kelley and Knowles (2016) say that modern trends like STEM education have appeared to fulfill this integration. The STEM acronym was introduced in 2001 by scientific administrators at the U.S. National Science Foundation (NSF) (2022). The organization previously used the acronym SMET when referring to the career fields in those disciplines or a curriculum that integrated knowledge and skills from those fields. However, they later preferred the term STEM instead.

STEM education is an approach that focuses on the integration of four subjects together, science, technology, engineering, and math in an applied approach (Hom, 2014). This integration is based on real-world applications. However, the desire to integrate subjects did not stop (Ormancı, 2020). There was an essential need to integrate the Arts and design into the other four subjects. This desire has brought to the world a broader educational system, STEAM. Riley (2021) defines STEAM Education as an approach to learning that uses Science, Technology, Engineering, the Arts, and Mathematics as access points for guiding student inquiry, dialogue, and critical thinking. STEAM provides teachers, especially primary stage teachers, with the power that enables them to employ project-based learning (Taylor, 2019)

This power also helps them create an inclusive learning environment in which all students can engage, participate, and learn confidently. Teaching would become more collaborative where teachers of different subjects team up to bring exclusive outcomes. This collaboration will produce experienced cooperative teachers that reflect a positive image to their students to imitate (Chu et al. 2019).

According to the Ministry of Education in the USA, in an ever-changing and increasingly complex world, young people are willing to bring knowledge and skills to solve problems, understand information, and know how to implement it. It is more important than ever to collect and evaluate evidence to make decisions (Taylor, 2019). The Ministry of Education has recently started to introduce the idea of STEAM education gradually into schoolbooks.

The STEAM approach is a new trend which has not yet entered our educational systems in Jordan except for one or two schools that have adopted the STEAM approach on their own. These attempts do not live up to the expectations. Therefore, the need to adopt this approach has emerged strongly among those who are interested in educational issues, starting with the primary stages (Saleem, 2021). The researcher needs to know first how teachers think about this system, what it is, how it will be applied, and whether they have enough awareness about this approach (Riley, 2021).

Knowing the level of metacognitive awareness of teachers in the primary stage is the first step that the researcher needs to measure the educational systems that imposed themselves globally and locally soon. Therefore, specialists cannot go into the mechanisms of implementing the STEAM approach, before realizing the extent to which teachers are aware of such systems (Margot & Kettler, 2019). Consequently, this study seeks to measure the level of metacognitive awareness of primary school teachers in Jordan about the STEAM approach.

Literature Review

In this section, the concepts of metacognition and metacognitive awareness about STEM and STEAM education are focused on in the current literature. Therefore, revealing the current studies and any potential gaps is aimed.

Hughes and Partida (2020) implemented a quantitative exploratory study to measure the professional development (PD) experience and the associated Metacognitive comprised preservice STEM education teachers (N = 11) enrolled in a dual teaching certification and master's in education program. The researcher found it necessary to address the Metacognitive Awareness of the STEM approach and then find methods to promote it.

Kustiana et al., (2020) aimed to analyze the metacognitive skills and creative thinking of students in STEM education in senior high school, 150 students were involved in the study. The researchers found that practicing the biotechnology material by students in senior high school would be more meaningful if shared with STEM education.

Mutambuki et al. (2020) believed that metacognition and active learning have benefits on student performance. They investigated differences in performance in General Chemistry between the treatment group exposed to the explicit teaching of metacognition combined with active learning and their counterparts who were exposed to active learning alone (comparison group). The results of the study showed that metacognitive instruction infused with active learning has a significant effect on student performance in General Chemistry.

ElSayary (2021) investigated the factors that affect teaching and assessing students' creativity. The researcher used a mixed-method design to answer the research questions. The study was conducted in a private school in the UAE. The participants were science, technology, language art, and mathematics teachers (n=30). The findings of this study highlighted the importance of motivation, cognition, and metacognition in attempting to influence students' creativity in STEAM classes.

Kandemir and Karadeniz (2020) believed that mathematical modeling activities did not focus on existing STEM integration practices. They focused their study on Mathematical modeling using STEM integration practices. They added that the theories of both metacognition and social interaction development could promote teachers' abilities to focus better on STEM integration. The participants of the study were pre-service teachers who were in a mathematics-teaching program at a university located in the west part of Turkey.

Mulyani and Arif (2021) supposed that good learning is learning that combines an approach with an appropriate learning model. The study was done to realize the implementation of a learning model with an approach to students' metacognitive thinking ability. The study is conducted with a quantitative experiment, and qualitative descriptive data analysis techniques. Data gathering instruments were written tests with multiple choices. The results recommended at the end the importance of improving metacognitive thinking ability using the right approaches. The study recommended the importance of developing metacognitive activities for pre-service teachers.

Morphew (2021) proved that students need to engage in accurate metacognitive monitoring to make appropriate metacognitive control decisions. The sample consisted of students attending an introductory Physics Course. The results indicate that some students improve the accuracy of their predictions over a semester. However, low-performing students are less accurate at predicting their exam grades and tend not to improve their metacognitive standards over a semester.

As seen in the literature, previous STEAM education studies on metacognition and metacognitive awareness have mostly been conducted with students and preservice teachers. As stated by Riley (2021), metacognitive awareness of teachers is of importance and no studies could be found in our search of the literature that reveals the metacognitive awareness of primary school STEAM teachers. This study aims to fill this particular gap and provide a specific point of view into the current literature.

Methods

Research Design

This study followed the descriptive quantitative survey method to measure the Metacognitive level of awareness about STEAM education among primary school teachers in Jordan. The researcher, on the other hand, followed a different descriptive-analytic approach to examine the degree of difference in metacognitive awareness about STEAM education among Jordanian Primary schoolteachers of STEAM fields, according to their fields, school type, experience, and specialization. The purpose of the study pushes us to limit the participants of the study according to these criteria in order to collect subject-spesific data to be used in answering our research problems.

Participation

Purposive sampling was used to determine the study sample, which consisted of 370 male and female teachers working in public and private schools in the Amman / Madaba governorates. Choosing this sample was mainly based on their knowledge of the STEAM approach. Beyond this, the participants were sought to have various experiences in their fields of expertise, school types and needed to come from different STEAM fields as well. Table 1 shows the distribution of the sample study according to specialization, experience, and school type.

Table 1

Distribution of the Study Sample According to Personal and Demographic Variables

Specialization	Science		Computer Science		Math		Social studies and humanities		
School type	Public	Private	Public	private	Public	private	Public	private	
1-2	5	11	2	1	5	4	10	26	64
3-5	11	3	5	9	2	4	9	10	53
> 5	15	15	25	20	10	36	88	44	253
TOTAL	31	29	32	30	17	44	107	80	370

Data Collection Instrument

We adapted a five-point Likert-type Metacognitive awareness inventory for teachers (MAIT) to measure metacognitive awareness among primary school teachers about the STEAM approach (Balcikanli, 2011). It consisted of two main parts, knowledge about cognition with the following subheadings Declarative knowledge (8 items), procedural knowledge (4 items), Conditional knowledge (5 items), and the Regulation of cognition with the following subheadings: planning (7 items), comprehension monitoring (7 items), information management strategies (9 items), debugging strategies (4 items) and evaluation (5 items). To measure the reliability of the instrument the Cronbach's alpha coefficient was calculated to measure the reliability according to the pilot sample responses, which consisted of thirty teachers. The overall reliability coefficient of the instrument was .92 according to Cronbach's alpha, which indicates that the instrument has high reliability. It also indicates its readiness and suitability to be applied to the study sample.

Data Analysis

The data collected were analyzed via descriptive statistics. In the analyses, mean scores from the inventory, standard deviations, ranks, and the relative importance of subdomains were considered. The relative importance of subdomains was analyzed using Oxford's (1990) conversion of frequencies and mean scores as Low: 1 - 2.29, Medium: 2.3 - 3.59, High: 3.6 -5 or higher.

The data then, were checked for Levene's Test of Equality and analyzed via inferential statistics to see if the variables chosen differed meaningfully among the research sample. For this aim, ANOVA test was performed, and the finding are presented in the next section.

Findings and Discussion

The findings of the level of knowledge about cognition and regulation of cognition are presented in Table 2.

Table 2

Means and Standard Deviations of Teacher Responses to the Main Domains and Sub-Domains of the Metacognitive Awareness Inventory

Subdomains	Mean	Standard deviation	Rank	Relative importance
Declarative knowledge	3.47	.51	2	Medium
Procedural knowledge	2.28	1.11	3	Low
Conditional knowledge	3.92	.67	1	High
Knowledge about cognition	3.32	.51	Medium	
Planning	3.94	.60	1	High
Information management strategies	3.88	.62	4	High
Comprehension Monitoring	3.88	.60	**3**	High
Debugging Strategies	2.84	.94	5	Medium
Evaluation	3.89	.62	2	High
Regulation of Cognition	3.77	.55	High	
overall performance (Metacognitive Awareness)	3.61	.51	High	

It is noted in Table 2 that the mean Metacognitive Level of awareness about STEAM education among primary school teachers in Jordan from the point of view of the teachers as a whole is (3.61), with a standard deviation of (.51), with a high degree. The mean of the Regulation as a whole was higher than that of the knowledge of cognition.

The highest area related to knowledge about cognition was conditional knowledge (M=3.92, SD=.67), with a high degree. Declarative knowledge came in second place (M=3.47, SD=.51), and with a high degree. In the third place came procedural knowledge (M=2.28, SD=1.11), with a low degree. Knowledge about cognition came last (M=3.32, SD=.51) with a medium degree.

The highest domains related to Regulation of cognition were the planning domain with (M=3.94, SD=.60), with a high degree, and the evaluation domain came in the second place with

(M=3.89, D=.62), and a high degree, and so on for the rest of the fields. The Debugging Strategies came last (M=2.84, SD=.94), with a medium degree.

Level of Metacognitive Awareness in Declarative Knowledge

The findings of the means, standard deviations, and rank of responses for the domain of declarative knowledge are presented in Table 3.

Table 3

Means, Standard Deviations, and Rank of Responses for the Domain of Declarative Knowledge

Item	Mean	Standard deviation	Rank	Relative importance
I realize my strengths and my weaknesses in my ability to use the STEAM approach.	3.61	1.10	1	High
I can specify what kind of information could be most important for teaching my students according to the STEAM approach.	3.50	1.26	3	High
I'm good at organizing information when teaching according to the STEAM approach	3.42	1.27	6	Medium
I know what the student expects me to teach him, which is not against the STEAM approach	3.54	1.17	2	High
I am good at remembering the information related to the use of STEAM in teaching.	3.46	1.22	5	Medium
I feel like I have control over my students' teaching, following the STEAM approach.	3.36	1.20	8	Medium
I can judge how successful what I taught according to the STEAM approach	3.36	1.23	7	Medium
I teach better when I pay more attention to using the STEAM approach.	3.49	1.15	4	Medium
Declarative Knowledge	3.47	.51		Medium

Table 3 shows that the means for Declarative Knowledge ranged between (3.36 - 3.61), with standard deviations between (1.10 - 1.27). The declarative knowledge as a whole obtained a mean of (3.47) with a standard deviation (.51) and a medium degree of appreciation. “I realize my strengths and my weaknesses about my ability to use STEAM approach.” came in the first rank, with (M=3.61, SD=1.10), with a high degree of estimate. Item (20) came in the last rank, which states,” I feel like I have control over my students' teaching, following STEAM approach” with (M=3.36, SD=1.20), with a medium degree of Metacognitive Awareness.

The Findings of the Level of Metacognitive Awareness in Procedural Knowledge

The values of means, standard deviations, and ranks were calculated. Table 4 shows the results of the analysis.

Table 4

Means, Standard Deviations, and Rank of Responses for the Domain of Procedural Knowledge

Item	mean	Standard deviation	rank	Relative importance
I try to employ teaching strategies that I used before and that was successful if I taught according to the STEAM approach when teaching	2.33	1.32	1	Low
I have a specific goal for every teaching strategy that can be used in teaching according to the Steam approach	2.26	1.32	3	Low
I am familiar with the strategies I use based on the STEAM approach when I teach my students.	2.31	1.32	2	Low
I find myself automatically using useful teaching strategies that match the STEAM approach.	2.21	1.30	4	Low
Procedural knowledge	2.28	1.11		Low

Table 4 shows that the means for procedural knowledge ranged between (2.21 - 2.33), with standard deviations between (1.30 - 1.32). The procedural knowledge as a whole was obtained (M=2.28, SD= 1.11). Item (3) states "I try to employ teaching strategies that I used before and that was successful if I taught according to the STEAM approach When teaching" came in the first rank, with (M=2.33, SD=1.32) and a low level of Metacognitive Awareness in Procedural Knowledge. Item (33) which states "I find myself automatically using useful teaching strategies that match the STEAM approach" came in the last rank, with (M=2.21, SD=1.30) and a low level of Metacognitive Awareness in Procedural Knowledge.

The Findings of the Level of Metacognitive Awareness in Conditional Knowledge

The values of means, standard deviations, and ranks were calculated. Table 5 shows the results of the analysis.

Table 5

Means, Standard Deviations, and Rank of Responses for the Domain of Conditional Knowledge

Item	mean	Standard deviation	Rank	Relative importance
I teach better when I have more knowledge about the subject. I will teach following the STEAM approach in education.	3.98	.93	**1**	High
I use different education strategies according to the situation, which suits the STEAM approach	3.97	.87	**2**	High
I can motivate my students to learn according to the STEAM approach when they need it.	3.89	.90	**4**	High
I use my intellectual strength to compensate for my weaknesses in teaching according to the STEAM approach I use my intellectual strengths	3.89	.87	**3**	High
I can decide when to use each strategy that is most effective according to the STEAM approach.	3.85	.83	**5**	High
Conditional Knowledge	3.92	.67		High

Table 5 shows that the means for the conditional Knowledge ranged between (3.85-3.98), with standard deviations between (.83-.93). The conditional knowledge as a whole was obtained (M=3.92, SD=.67) and a high level of Conditional Level. Item (15), which states, "I teach better when I have more knowledge about the subject I will teach following STEAM approach in education" came in the

first rank with (M=3.98, SD=.93. In addition, item (35), which states "I can decide when to use each strategy that is most effective according to the STEAM approach" came in the last rank with (M=3.85, SD=.83), with a high level of Metacognitive Awareness in the Conditional knowledge.

The Findings of the Level of Metacognitive Awareness in the Planning Domain

The values of arithmetic means, standard deviations, and ranks were calculated. Table 6 shows the results of the analysis.

Table 6

Means, Standard Deviations, and Rank of Responses for the Domain of Conditional Knowledge

Item	Arithmetic mean	Standard deviation	Rank	Relative importance
I need to increase the frequency of teaching time to save more time to fit in with the STEAM approach.	3.97	.80	**2**	High
I think about what students need before any learning process starts according to the STEAM approach	4.05	.82	**1**	High
I can set specific targets that correspond to the Steam approach. before the beginning of any lesson	3.94	.84	**3**	High
I ask myself questions about the scientific subject and how to follow the STEAM approach in teaching it before I start the lesson.	3.94	.85	**4**	High
I encourage my students to consider several ways to use the STEAM approach to solve problems and choose the best.	3.92	.91	**5**	High
I need to read the instructions showing the sequence of using the STEAM approach in activities carefully before I start the task	3.87	.88	**7**	High
I organize my time to achieve my goals so that they best match the STEAM approach.	3.91	.89	**6**	High
Planning	3.94	.60	High	

Table 6 shows that the means for the planning domain are between (3.87-4.05), with standard deviations from (.80-.91). The Planning domain as a whole obtained (M=3.94, SD .60) a high level of Awareness of Planning. Item (6), which states," I think about what students need before any learning process starts according to the STEAM approach", came in the first place with (M=4.05, SD=.92). Item 42 states "I need to read the instructions showing the sequence of using the STEAM approach in activities carefully before I start the task" (M=3.87, SD=.88), and a high level of Metacognitive Awareness in Planning came in the last place.

The Findings of the Levels of Metacognitive Awareness in Information Management Strategies

The values of means, standard deviations, and ranks were calculated, and Table 7 shows the results of the analysis.

Table 7

Means, Standard Deviations, and Rank of Responses for the Domain of Information Management Strategies

Item	mean	Standard deviation	rank	Relative importance
I slow down when I find important information in the lesson that does not fit the STEAM approach.	3.90	.83	***2***	High
I focus my attention consciously on important information in the teaching content based on the STEAM approach	3.97	.83	***1***	High
I focus on the meaning and the importance of new information when teaching according to the STEAM approach	3.90	.87	3	High
I create my examples to make scientific content built according to the STEAM approach more useful	3.90	.85	4	High
I need to draw pictures or diagrams to help students understand while learning according to STEAM	3.87	.87	***6***	High
I try to transform new information into easier words to match the use of the STEAM approach.	3.87	.85	***5***	High
I will use the text organizational structure to help students learn by STEAM approach	3.86	.85	***7***	High
I try to divide the STEAM teaching process into smaller steps.	3.84	.95	***8***	High
I focus more on the general meaning than the details when teaching according to the STEAM approach.	3.79	.90	***9***	High
Information management strategies	3.88	.62	High	

Table 7 shows that the means for Information management strategies ranged between (3.79-3.97), with standard deviations between (.85 - .95). The information management strategies as a whole (M=3.88, SD=.62). Item (13) which states, "I focus my attention consciously on important information in the teaching content based on the STEAM approach" came in the first rank (M=3.97, SD=.83). Item (47) came in the last rank, which states "I focus more on the general meaning than the details when teaching according to STEAM approach" with (M=3.79, SD=.90), and a high level of Metacognitive Awareness in the domain of Information management strategies.

The Findings of the Level of Metacognitive Awareness in Comprehension Monitoring

The values of means, standard deviations, and ranks were calculated. Table 8 shows the results of the analysis.

Table 8

Means, Standard Deviations, and Rank of Responses for the Comprehension Control Domain

Item	Arithmetic mean	Standard deviation	Rank	Relative importance
I ask myself periodically if I am meeting the goals that enable me to teach according to the STEAM approach	4.03	.81	*1*	High
I consider several alternatives to any problem I might encounter in teaching, according to the STEAM approach.	3.96	.78	*2*	High
I ask myself if I considered all the options that STEAM can offer when solving a problem	3.90	.79	*3*	High
I feel like I have control over my students' teaching, following the STEAM approach.	3.77	.92	*7*	High

If I teach according to the STEAM approach, I need to analyze the benefits of the strategies used during my teaching.	3.81	.86	*6*	High
I feel like I am going to stop regularly to check students' understanding to ensure that their learning is effective according to Steam	3.88	.83	*4*	High
I ask myself questions about the harmony and fluidity of my teaching process when I teach according to the STEAM approach.	3.84	.88	*5*	High
Monitoring comprehension	3.88	.60	High	

Table 8 shows that the means for the Monitoring comprehension ranged between (3.77-4.03) and standard deviations from (.78-.92). The Monitoring comprehension as a whole has (M=3.88, SD=.60). Item (1) which states, "I ask myself periodically if I am meeting the goals that enable me to teach according to STEAM approach" came in the first place with a mean (M=4.03, SD=.81), with a high degree of appreciation. Item (21) which states, "I feel like I have control over my students' teaching, following STEAM approach" came in the last place with (M=3.77, SD=.92), with a high level of Metacognitive Awareness in Monitoring comprehension.

The Findings of the Level of Metacognitive Awareness in Debugging Strategies

The values of means, standard deviations, and ranks were calculated, Table 9 shows the results of the analysis.

Table 9

Means, Standard Deviations, and Rank of Responses for the Domain of Debugging Strategies

Item	Mean	Standard deviation	Rank	Relative importance
I will ask others for help if I find something that does not make sense to me, and I need to teach it to my students according to the STEAM approach.	2.86	1.17	2	Medium
I will change my teaching strategies when I notice that students fail to learn according to the STEAM approach	2.76	1.19	4	Medium
I need to reassess my assumptions when I am confused while teaching according to the STEAM approach.	2.81	1.15	3	Medium
If I teach according to the STEAM approach, I need to stop and come back to new, unclear information in order to reformulate it.	2.93	1.13	1	Medium
Debugging strategies	2.84	.94		Medium

Table 9 shows that the means for debugging information ranged between (2.76-2.93), with standard deviations between (1.13-1.17). The debugging strategies as a whole were (M=2.84, SD=.94). Item (49) which states, "If I teach according to STEAM approach, I need to stop and come back to new, unclear information in order to reformulate it" came in the first place, with (M=2.93, SD 1.13). Item (40) which states, "I will change my teaching strategies when I notice that students fail to learn according to STEAM approach" came in the last place, with (M=2.76, SD=1.19), with a medium level of Metacognitive Awareness in Debugging Information.

The Findings of the Level of Metacognitive Awareness in Evaluation

The values of a means, standard deviations, and ranks were calculated, and Table 10 shows the results of the analysis.

Table 10

Means, Standard Deviations, and Rank of Responses for the Domain of Evaluation

Item	Mean	Standard Deviation	Rank	Relative Importance
I can figure out how well I performed just after I finish giving a new lesson using the Steam approach.	3.89	.77	3	High
At the end of each lesson, I ask myself if there is an easier way to use the STEAM approach in teaching students	4.01	.90	1	High
I will make sure to summarize what I learned after he finished teaching according to the STEAM approach	3.90	.92	2	High
I will ask myself how to achieve my goals well as soon as I finish teaching according to my approach.	3.83	.85	**4**	High
I ask myself if I have specified all the options assumed by the STEAM approach after solving a problem	3.83	.80	**5**	High
Evaluation	3.89	.62	High	

Table 10 shows that the means of the Evaluation domain ranged from (3.83-4.01), with standard deviations from (.77-.92). The field as a whole was obtained (M=3.89, SD= .62). Item (19) states, "At the end of each lesson, I ask myself if there is an easier way to use the STEAM approach in teaching students" came first with (M=4.01, SD=.90). Item (38) which states "I ask myself if I have specified all the options assumed by STEAM approach after solving a problem" came in last place, with (M=3.83, SD= .80), with a high level of Metacognitive Awareness in Evaluation.

The Findings of the Effect of the School Type, Experience, and Specialization on Metacognitive Awareness among Jordanian Primary School Teachers

To calculate the difference in determining the Metacognitive awareness about STEAM education among Jordanian Primary School Teachers, according to School type, Experience, and Specialization, the values of the means and the standard deviations of the domains of the questionnaire and the overall Metacognitive Awareness were extracted. Means and standard deviations of the questionnaire domains and the questionnaire as a whole for the responses of the teachers according to the specialization, school type, and experience variables.

Table 11

The Means and the Standard Deviations of the Level of Metacognitive Awareness According to the School Type, Experience, and Specialization

School type	Experience	Specialization	Number	Means	Standard Deviation
Private	2 – 1	Science	11	3.37	.56
		computer science	1	4.14	.00
		Mathematics	4	3.24	.41
		Social and human sciences	26	3.70	.46
		Total	42	3.58	.51
	5 – 3	Science	3	3.67	.60
		computer science	9	3.46	.21
		Mathematics	4	3.85	.30
		Social and human sciences	10	3.30	.42
		Total	26	3.48	.40
	>5	Science	15	3.65	.33
		computer science	20	3.59	.51
		Mathematics	36	3.87	.57
		Social and human sciences	44	3.69	.37
		Total	115	3.72	.47
	Total	Science	29	3.55	.46
		computer science	30	3.57	.44
		Mathematics	44	3.81	.56
		social and human sciences	80	3.65	.42
		Total	183	3.66	.47
Public	2-1	Science	5	3.39	.54
		computer science	2	2.97	.82
		Mathematics	5	3.99	.28
		social and human sciences	10	3.46	.44
		Total	22	3.52	.52
	5-3	Science	11	3.74	.33
		computer science	5	3.13	.46
		Mathematics	2	3.07	.07
		social and human sciences	9	3.37	.51
		Total	27	3.46	.47
	>5	Science	15	3.60	.75
		computer science	25	3.67	.51
		Mathematics	10	3.85	.40
		Social and human sciences	88	3.54	.53
		Total	138	3.59	.55
	Total	Science	31	3.62	.59
		computer science	32	3.54	.56

School type	Experience	Specialization	Number	Means	Standard Deviation
		Mathematics	17	3.81	.43
		Social and human sciences	107	3.52	.52
		Total	187	3.56	.53
Total	2 – 1	Science	16	3.38	.53
		computer science	3	3.36	.89
		Mathematics	9	3.66	.51
		social and human sciences	36	3.63	.46
		Total	64	3.56	.51
	5 – 3	Science	14	3.73	.38
		computer science	14	3.34	.34
		Mathematics	6	3.58	.46
		social and human sciences	19	3.34	.45
		Total	53	3.47	.43
	>5	Science	30	3.62	.57
		computer science	45	3.63	.50
		Mathematics	46	3.87	.53
		social and human sciences	132	3.59	.49
		Total	253	3.65	.52
	Total	Science	60	3.58	.53
		computer science	62	3.56	.50
		Mathematics	61	3.81	.52
		social and human sciences	187	3.57	.48
		Total	370	3.61	.51

It is noted from Table 11 that there are differences in the means for the responses of the study sample in the light of the variable of school type, and experience, and there were no differences in the mean in the light of the specialization variable.

Before using the multi-Anova test, the researcher verified the assumption of variance homogeneity, and Table 12 shows the results of Levene's Test of Equality.

Table 12

Levene's Test of Equality Results

Metacognitive Awareness	Levene Statistic	Df1	Df2	Sig.
	1.455	22	346	087

Table 12 results show no statistically significant differences in variances between subgroups (at α=.05), with Levene's test value (1.455) at sig level (.087)

These findings indicate that the homogeneity requirement in the study data, which is equal to the variation in the Metacognitive Awareness variable, has been achieved in the subgroups under study.

Table 13 shows the results of the three-way –ANOVA test to measure the effect of the school type, Experience, and specialization on Metacognitive Awareness level among primary school teachers.

Table 13

Results of the three-way –ANOVA test

Source of variance	Sum of Squares	Degree of freedom	Mean Square	value of F	Significance indication.	Eta Squared
Workplace	.673	1	.673	2.798	.095	.008
Experience	1.938	2	.969	4.027	.019**	.023
Specialization	.471	3	.157	.653	.582	.006
School type * Experience	.372	2	.186	.772	.463	.004
School type * Specialization	.827	3	.276	1.145	.331	.010
Experience * Specialization	1.692	6	.282	1.172	.321	.020
School type * Experience * Specialization	3.581	6	.597	2.480	.023**	.041
Error	83.254	346	.241			
Total	92.808	369				

Note ** Significance level (α = .05)

The following results are noted in Table 13:

The statistical difference (α =.05) in Metacognitive awareness level about STEAM education among Jordanian Primary School Teachers was attributed to the school type variable (F =2.798, sig=.095), and this value was not statistically significant at the indication level (.05 = α).

Statistically significant differences (α= .05) in Metacognitive awareness about STEAM education among Jordanian Primary School Teachers were attributed to the experience variable (F=4.027, sig=.019) which was in favor of teachers with more than 5 years of experience.

There are no statistically significant differences (α= .05) in Metacognitive awareness levels about STEAM education among Jordanian Primary School Teachers attributed to the Specialization variable (f =.653, sig =.582).

There are no statistically significant differences (α= .05) in Metacognitive awareness levels about STEAM education among Jordanian Primary School Teachers attributed to the bilateral interaction between School type and Experience, where the value (F) (.772) was at an indicative level (.463) and this value was not statistically significant at the indication level (.05 = α).

There are no statistically significant differences (α = .05) in Metacognitive awareness about STEAM education among Jordanian Primary School Teachers attributed to the interaction between the school type and the Specialization (F=1.145, sig=.331)

There are no statistically significant differences (α=.05) in Metacognitive awareness levels about STEAM education among Jordanian Primary School Teachers due to the bilateral interaction between Experience and Specialization (F=1.172, sig=.321)

There are statistically significant differences (α= .05) in Metacognitive awareness about STEAM education among Jordanian teachers attributed to the triple interaction between Work Place, Experience, and Specialization, where (F=2.480, sig= .023).

To detect the reasons for the different results in the light of the experience variable, LSD comparisons test were used for teachers' responses to Metacognitive Awareness levels depending on the experience variable, and Table 14 shows the results of the analysis.

Table 14

Post-hoc Comparisons of Responses about Metacognitive Awareness in the Light of the Experience Variable

Study tool	Experience levels	average	1 - 2	3 – 5	>5
Metacognitive Awareness	1 – 2	3.56	-	.090	.090
	3 – 5	3.47		-	.18**
	>5	3.65			-

Note ** Significance level (α = .05)

Table 14 shows that there is only a difference in Metacognitive Awareness between those whose experience was 3-5 years, and for those whose experience was more than (5) years, where the value of the mean was higher. There is no difference in Metacognitive Awareness level in the rest of the binary comparisons.

Discussion, Conclusions and Recommendations

The Metacognitive level of Awareness about STEAM education among primary school teachers in Jordan in the knowledge about cognition was medium. While the level of Awareness about STEAM education in the regulation of cognition was high. This result is attributed to the urgent need for teachers to cope with the rapid growth in all aspects of life including the field of education. It reflects the importance of Metacognitive awareness in education as it gives a better method to understand the aim of education. It is difficult to enhance the teaching process if we do not have a moderate level of Metacognitive awareness about the methods we are using. If one of the goals of education is to prepare students to be lifelong learners, it is critical to assist students in being aware of themselves as learners and taking charge of their actions. This movement has attracted teachers' interests and pushed them to progress in their teaching methods. This finding is in line with the study, which was conducted by Sevian et al. (2018). They showed in their study that over the last few years, research regarding STEM education has viewed increasing improvement, attracting considerable interest among students and teachers. The researcher found that the Metacognitive level of awareness has a great role in cognition as teachers can finally be aware of what they teach and be able to cognize and understand the whole teaching process. This result agrees with the result that was reached in his study. Primary school teacher trainees utilized "self-control," "cognitive strategy," "self-evaluation," and "self-awareness" the most among the metacognitive strategies they used (Boice et al. 2021).

The level of Metacognitive Awareness about the STEAM approach in the regulation of cognition among primary school teachers was high. This result is attributed to the fact that teachers were forced to online their lessons and organize their work in a few months during the Corona epidemic. The results showed the effect of the Metacognitive level of awareness on the regulation of cognition as the metacognitive level of awareness does not stop on clarifying the cognition and increasing the student's self-awareness, it helps with using this awareness and organizing it to enrich the teaching process. This result agrees with (Rowsome et al., 2014) in which the researcher focused on the importance of self-regulation among teachers and encouraged other researchers to search deep in detail in this field.

The level of Metacognitive Awareness about the STEAM approach among teachers in declarative knowledge was medium. This result indicates that teachers can identify the most proper

information that must be given to the students in the class. In addition, they are somewhat aware of the level of awareness of their strong and weak points in using STEAM education, and this is considered as a first step to classifying strengths to depend on them and then improving their weaknesses. The fact that the ministry of education has been trying hard to cope with the recent improvements concerning education can be another reason for this result. Their efforts are beneficial and lead to well-trained teachers who know quite well the importance of declarative knowledge and care about their methods in teaching classes. This is quite clear in (Sangster et al., 2013) as they showed how declarative knowledge made a difference among students who wanted to learn the language more effectively. The declarative knowledge of teachers is as important as the students' declarative knowledge because teachers cannot help students unless they are aware of their abilities. Learners' knowledge and opinions about themselves have an impact on their ability to learn and solve problems and (Akyol & Garrison, 2011) quite agree with this.

The level of Metacognitive Awareness about the STEAM approach among teachers in procedural knowledge was low and this result indicates that teachers are still using the familiar teaching processes that they are comfortable with and avoid getting away from their comfort zone. They still follow the traditional methods of teaching their students and do not pay much to the process they should prepare and follow according to modern education. Procedural knowledge relates to knowing how to do things as it helps with applying knowledge to the completion of a procedure or process. Thus, it is knowledge about how to implement the teaching. For instance, they do not prepare for the science lesson. They do not as well prepare methods to apply the lesson that suit the STEAM approach. This requires them to know the process and the time to apply the process in various situations. Nevertheless, if they work harder their metacognitive awareness helps them to choose the methods that match the new approaches such as the STEAM approach. This result is attributed to the fact that teachers' performance increases according to their Awareness of providing suitable conditions for the students and asking themselves why their methods will work. This is what helps them in making the best decisions about the class and makes them modify and improve what they have missed from the procedural knowledge, as they understand the best conditions and seek for achieving them. The determination of when and why specific processes or skills should transfer; knowledge of when and why to use learning procedures; application of declarative and procedural knowledge with specific conditions presented; and students can obtain knowledge through simulation. These results go in line with (Nagro & Monnin, 2022) through which the importance of conditional knowledge and its effects were focused.

The result is attributed to the nature of teachers' role in school and inside the classroom. It emphasizes the fact that the teachers' awareness of time and goals is high as they organize the whole class before it starts. They prepare the lesson and the way they will apply it to suit the STEAM approach. Metacognitive awareness in planning is not restricted to timing only; it includes planning for each step in the class (the class time, the class content, and how the content will be applied to match the scientific theories with the experimental approach). Planning entails selecting metacognitive strategies and allocating resources appropriately. In addition, setting goals, activating relevant prior knowledge, and allocating learning resources through practices such as time management are all part of it. These facts go in line with (Dolgopolovas & Dagienė. 2021).

From the results, we can see that the responsibilities of teachers to manage the classes are high as they control and choose each suitable detail that could help and fit the students, and this is how Metacognitive Awareness controls their choices to help them to manage the teaching process effectively. It also helps them with finding the best information, teaching techniques, how they control the lessons, and what they are teaching the students. This increases their awareness of the content of the lessons much better than letting the classes go by the traditional methods. According to the Regulation of cognition, Metacognitive skills are the voluntary control that individuals exert over their cognitive processes (Desoete & Ozsoy, 2009) and the purposeful application of cognitive behaviors at a specific moment (Van Der Stel & Veenman, 2014). Metacognitive skillfulness manifests itself in

information management, planning, monitoring, and evaluation (Van Der Stel & Veenman, 2014). As a result, it refers to information management that is as efficient as possible (Kohen & Kramarski, 2018).

The result indicates that teachers were able to measure their abilities in meeting the STEAM approach in teaching if they are taking the right path. It also indicates that they think about several alternatives when it comes to change or if they need to examine the benefits of their approaches. Therefore, this provides a cautious following system for the teaching approach that helps with providing the best teaching method for the STEAM approach. The current knowledge and skill levels are monitored by reflecting on one's thought processes. What was mentioned previously goes in line with (Engel, 2021; Kohen & Kramarski, 2018). Monitoring strategies, for example, self-testing can help to check one's own comprehension and performance.

According to the results, we can see that Metacognitive Awareness is also working as a reference for the teachers to rethink what they cannot do or what to ask about efficiently. Therefore, they do not only give the students the information they need to be aware of, and they need to understand each word they are saying to match the STEAM approach. This helps them to ask each other and always find new solutions for classes and make them always ready for new methods in teaching to match students' needs, debugging strategies are used to correct comprehension and performance errors (Schraw & Dennison, 1994). It includes students correcting their mistakes and enhancing their understanding of their work (Kohen & Kramarski, 2018). In mathematics, for instance, students may reread something they do not understand or correct mathematical errors (Schraw et al., 2006) so, the same is for teachers who find what they do not understand and search for a solution.

We can see that Metacognitive Awareness is almost creating a chain of connected series that leads eventually to evaluating all the previous stages that teachers have been through starting with increasing their awareness of the information and what they are teaching the students and ending with how they could improve their methods and evaluate this improvement. This opens their minds to seek to choose the easiest and the most efficient ways to teach STEAM students to achieve the main goals of the curriculum, such as following a learning experience (Sarıoğlu et al., 2021), evaluating including analyzing the effectiveness of performance or strategy (Schraw & Dennison, 1994). This entails assessing the progress and effectiveness of one's learning and, as a result, re-evaluating one's goals and conclusions in response (Schraw, 1998), as well as reflecting on performance concerning required standards and goals (Kohen & Kramarski, 2018). In mathematics, for example, students may assess the appropriateness of a solution and decide to debug or find an alternative solution. Re-evaluating goals and conclusions, as well as revising predictions, are examples of this (Schraw, 1998). In the end, we can say that the level of Metacognitive Awareness is a whole teaching approach as it helps the teachers to improve themselves from zero and then to improve their methods in information delivery. It also helps with improving the information itself and choosing the best words and techniques that help their students.

There are no statistically significant differences between the means of Metacognitive Awareness of the STEAM approach among primary school teachers in Jordan, attributed to specialization, and in favor of teachers working in the private sector with more than five years of experience. This result indicates that though each specialization has its methods and ways of adapting Metacognitive Awareness, it all depends mainly on the teacher and his ability to mix the academic content and the way he could apply it. We can see that some specializations provide a space for the teachers to apply the STEAM approach in an easier way such as computer science as it mainly depends on practice. Mathematics for example depends on theories, which puts the teacher in a challenging position to create a proper approach. Science results in between, as science is a mixture between experiments and scientific theories that make the mission easier for the teacher. Durmuşçelebi and Kuşuçuran (2020) investigated the cognitive Awareness levels of education faculty students in terms of various variables. The specialization of the participants in the study with Science, Elementary Mathematics, Classroom, and Social Studies, teachers were found to have a high level of

knowledge, which agrees with what the current study concluded. Academic achievement and cognitive Awareness had a positive relationship, and the Specialization variable made a significant difference in cognitive Awareness. However, contrary to expectations, the findings revealed a significant negative relationship between the participants' logical thinking scores and their cognitive knowledge dimensions. Furthermore, according to the study's findings, the teachers' cognitive Awareness levels did not differ based on the specialization they studied.

From the results, we can see that experience plays the main role in the variation of the results, as experience enriches the teachers' knowledge and their methods to adapt to new conditions. As we mentioned before, the academic specialization affects how hard it would be for the teacher to adopt the STEAM approach so the experience would solve this problem and gives the teacher the courage to find solutions and apply new methods in teaching. We can see from the results that experience is the main factor when it comes to Metacognitive Awareness. According to the overall findings, teachers with a higher level of Metacognitive Awareness can produce students with high academic achievement (Palantis et al. 2018).

The results indicate that the school type plays an important role in the level of Metacognitive Awareness among teachers. Teachers who work in the private sector get better chances to improve (Jho et al., 2016). Private schools pay special attention to activities, and most of them teach international curricula, which justifies their high level of awareness about STEAM education. There is much yet to understand about how teachers' effectiveness with students depends on the characteristics and quality of the school as a school type

It is clear that the school type can enable or constrain good teaching. Teachers must have a school type that promotes their efforts in a variety of ways, and this agrees with (Bryk & Schneider, 2002). They discussed in their study the qualities of a school type that positively affects the level of metacognitive awareness of teachers. They focused on the school type that supplies the teachers with everything they need to promote and so produce good beneficial teaching.

Studies have shown clearly that the school type can either enable or constrain good teaching (Bryk & Schneider 2002). Thus, improving the conditions of the school as a school type can increase the capacity of schools to serve all students. The school as a school type can be understood as having many features that together create the context for individual teachers' work. All these aspects of the school type can mediate the effectiveness of teachers within their classrooms and influence their decisions during the teaching process.

Finally, we can say that the main factor in this process is measuring the teachers' metacognitive awareness of the STEAM approach. If they were aware of it, they would make use of their experiences and apply them to their subject whatever it is.

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